TOSHIBA

E6581186②

Inverter Application Manual

Maintenance of Inverter

Toshiba Schneider Inverter Corporation

— Contents —

1. Introduction

This manual describes important points and methods for performing the periodical inspection and maintenance of our general-purpose inverter.

* Electricians shall perform actual maintenance and inspection works in order to avoid any accident including electric shock.

2. Inspection and maintenance

This chapter describes “regular and periodical inspections” for normal use.

2.1. Regular inspection

Since electronic parts are easily affected by heat, install the inverter in a cool, well-ventilated, dust-free place for sustaining its original performance for a long time.

Purpose of regular inspection is to maintain indoor environment and to find sign of failure or malfunction by comparing current data on operation with recorded data on past operation.

Subject of inspection	Gist of inspection			Criteria of judgment
	Inspection item	Inspection cycle	Inspection method	
1. Indoor environment	1) Dust, humidity, gas 2) Dropping of water and other liquid 3) Room temperature	As occasion demands	1) Eye-check, thermometer, sense of smell 2) Eye-check 3) Thermometer	1) Improve bad atmosphere. 2) Pay heed to trace left of water drop. 3) Maximum temperature is 40°C (50°C inside cabinet)
2. Component parts and units	1) Vibration, noise		By feel (touch) of outside of the board	If there is something abnormal, open the door and check transformer, reactor, contactor, relay, cooling fan, etc. Stop the inverter as occasion demands.
3. Operation data (output side)	1) Load current 2) Voltage* 3) Temperature		Moving-iron type AC ammeter Rectifier type AC voltmeter Thermometer	Within the rating Little difference from data on normal status

*) Voltage is differently read depending on the measuring instrument. Use the same tester or voltmeter for every inspection and record measurement result each time. For details, refer to section 3.

■Check points:

1. With or without something unusual in the installation environment
2. With or without something unusual in the cooling system
3. With or without unusual vibration and noise
4. With or without overheat, discoloration
5. With or without unusual smell
6. With or without unusual motor vibration, noise and overheat

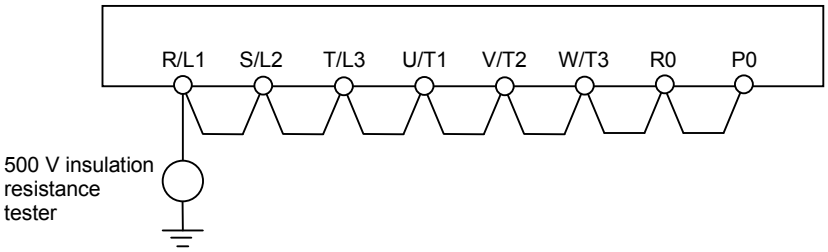
2.2. Periodical inspection

Make periodical inspection every three or six months depending on operating conditions.

■Points of inspection:

1. If any wire terminal screws are loosened. If any, tighten it with a screwdriver.
2. Make sure visually that there is neither poorly clinched part nor overheated clinch in wire terminals.
3. Check visually if there is any damage on wire or cable.
4. Clean up dust and soil. Absorb dust by a vacuum cleaner. Carefully clean the vents, printed circuit boards and so on. If those parts get dusty, it may cause an unexpected accident. Keep them clean.
5. If the inverter won't be used for a long time, turn it on every two years to check operation. Disconnect the motor and supply power to the inverter for five hours or more. It is recommended to use a step-up transformer to supply power at a low voltage first and to raise the voltage gradually.
6. If insulation test is needed, conduct it for the main circuit terminal board using a 500 V insulation resistance tester only. Never conduct insulation test for control terminals and circuit terminals on printed circuit boards except of the main circuit. For insulation test of motor, disconnect output terminals of U, V and W and conduct test for the motor only. In case of insulation tests of peripheral circuits other than motor, disconnect all cables so that no test voltage is placed on the inverter.
   Standard: Several MΩ or more. (Built-in noise filter cause to detect low insulation resistance.)
   *No insulation test shall be performed on VFS7e; otherwise, inner components may be damaged.

Note: Disconnect all cables from terminals of the main circuit terminal board, and conduct insulation test with the inverter only.



7. Do not make any pressure test, because it may cause damage to internal parts.
8. Voltage and temperature check
   Recommended voltmeter:
   For input side: Moving-iron type voltmeter (⫲)
   For output side: Rectifier type voltmeter (⏩)
   If ambient temperature is regularly measured at start time, during operation, and at stop time, recorded data will be helpful to find sign of failure or malfunction.

2.3. Component life

■ Replacement of expendable parts

The inverter incorporates a great deal of electronic parts including semiconductors. The following parts deteriorate because of their constructions, physical characteristics and aging. Continual use of such parts may cause the inverter to deteriorate in performance and to become faulty. Such being the case, the inverter needs periodical inspection for preventing itself from failure and deterioration.

Note: Service life of part may be affected by ambient temperature and operating conditions. Service life of main parts shown below is when the inverter is used in the normal environmental conditions.
Component life may differ depending on the model. Refer to the instruction manual of each model for details.

1) Cooling fan
Service life of the cooling fan to cool down heat generation parts is approximately 30000 hours (2 to 3 years under continuous operation). If it generates unusual noise or vibration, it is a sign of replacement.

2) Smoothing capacitor
The smoothing aluminum electrolytic capacitor of the DC main circuit deteriorates in characteristic because of influence of ripple current, etc. If the inverter is used in the normal operating condition, the smoothing capacitor needs to be replaced every five years. For the inverter of which applicable motor output is 3.7 kW or less, replace the smoothing capacitor together with the printed circuit board.
<Criteria of external inspection>
- No liquid leak
- Proper setting of safety valve
- Measurement of electrostatic capacity and insulation resistance

Note: For your safety, never replace components by yourselves.
Checking the operating time allows you to make a rough schedule of replacing each component.
Contact your Toshiba distributor for the replacement of the parts.

■Standard period of years to replace main component parts

If the inverter is used under the normal operating conditions (ambient temperature: 30°C on average, load factor: 80 % or less, 12-hours operation a day), standard period of years to replace main component parts is as shown below. The following period does not indicate the estimated end of service life of the part but indicates the period that failure rate of the part becomes sharply high thenceforth.

Part name	Standard period for replacement	Replacement method, others
Cooling fan	2 to 3 years	Replace with new one.
Smoothing capacitor	5 years	Replace with new one (depending on inspection result).
Breaker, relay, etc.	—	Depending on inspection result
Timer	—	Depending on operation hours
Fuse	10 years	Replace with new one.
Aluminum Electrolytic capacitors on printed circuit board	5 years	Change together with printed circuit board for new board (depending on inspection result).

(Extract from "Recommendation of periodical inspection of general inverter" published by Japan Electrical Manufacturers' Association.)

Note: Service life of part differs depending on operating environment.
- In case of using components at higher or highly variable temperature or humidity
- In case of frequently repeating operations and shutdowns
- In case of highly fluctuating power (voltage, frequency, waveform distortion, etc.) or load
- In case of installation under much vibration and impact
- In case of bad storage conditions prior to use or long-term storage
- In case of the power capacity being much greater than the inverter capacity

■ Determination of number of years for replacement:

In general, as shown on fig. 1, failure types of components are classified into three phases of initial, accidental, and wearing failures. Initial failures are controlled to be eliminated by manufacturers in the process of manufacture and inspection. However, as accidental failures randomly and unexpectedly occur before the progress of wear within the service lives of apparatus, it is difficult to take technical measures against accidental failures. At present, only the measures based on statistics can be taken.

Wearing failures occur near the end of service lives in the process of degradation or as a result of wear, and the failure rate is rapidly increased with the lapse of time. The tb point in the Fig. 1 indicates the time for replacement. It is to make the preventive maintenance more appropriately by replacing a particular component with new one at this point.

Component lives are greatly different depending on their use conditions.

a) For example, the life of relay is determined by the roughness of relay contact surface or the degree of wastage. Therefore, the value of contact current and the inductance portion of load can be factors of service life.

b) For instance, aluminum-electrolysis capacitors are mainly used as smoothing filter components in the inverter. Its service life is extremely changeable depending on temperature because of chemical reactions inside it. “Arrhenius’s law (double rule at 10°C)” is generally applied to the aluminum-electrolysis capacitor. It has a characteristic that the temperature rise by 10°C makes its life one half and the temperature drop by 10°C doubles it, which controls the life of inverter.

   When the inverter is used at high temperature, the aluminum-electrolysis capacitor may already be at the wearing failure stage even though other components are at their accidental failure stages. In this case, in order to use the inverter for a longer time, it is necessary to replace the aluminum-electrolysis capacitor.

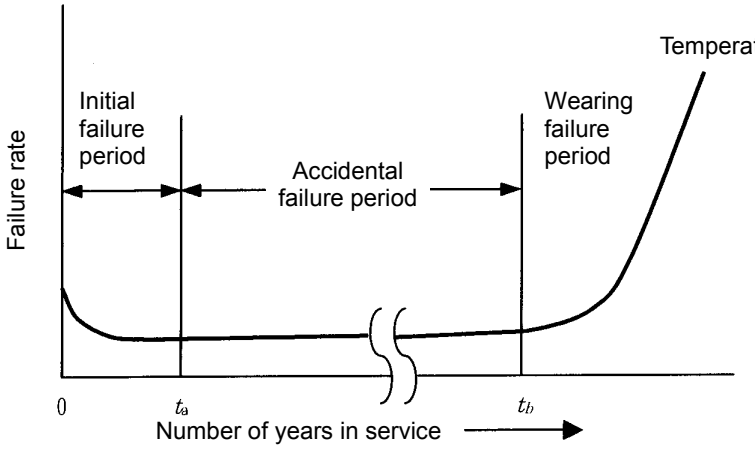


Fig. 1 Relation between number of years in service and failure rate

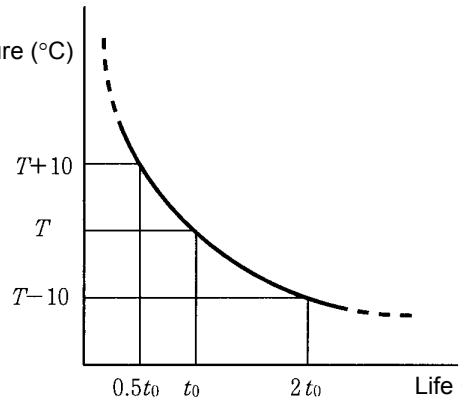


Fig. 2 Life of electrolysis capacitor

(Excerption from “Recommendation of periodical inspection of general inverter” published by the Japan Electrical Manufacturers’ Association)

2.4. Storage

When retaining the inverter out of operation temporarily or for a long time, pay heed to the following points.

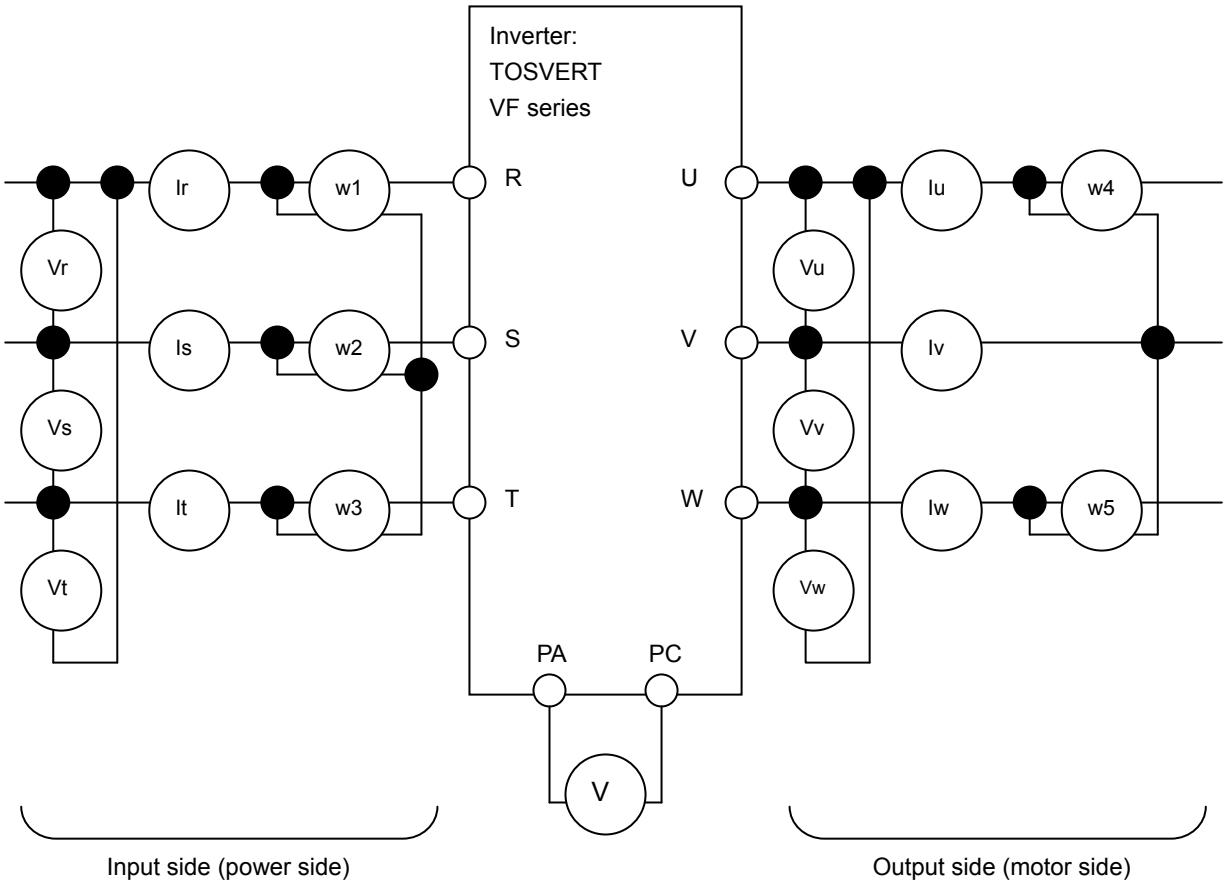
1. Keep the inverter in a well-ventilated place that is free from high temperature, high humidity, dust and metallic particles.
2. For the inverter whose printed circuit boards are covered with the charge-proof cover (black), don't remove the cover throughout retention. However, be sure to remove the cover before the inverter is turned on.
3. If the large-capacity electrolytic capacitor mounted in the inverter is left without power supply for a long time, it deteriorates in characteristics.
   If the inverter won't be used for a long time, turn it on for 5 hours or more once every two years in order to recover the characteristic of the electrolytic capacitor. At the same time, check operation status of the inverter. For turning on the inverter very seldom, it is recommended to use a step-up transformer to supply power at a low voltage first and then to raise the voltage gradually.

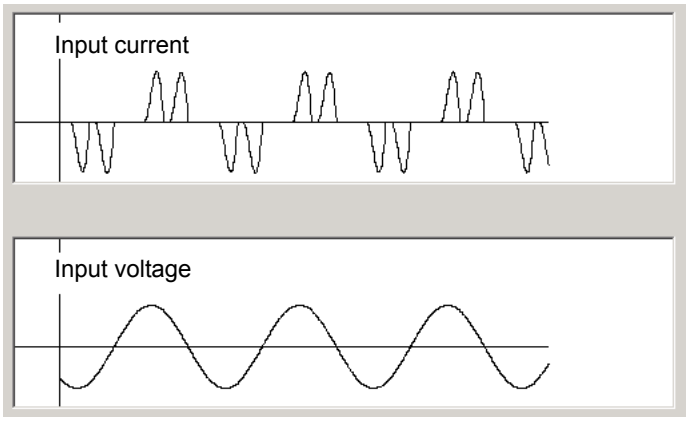
3. Measuring method of each part

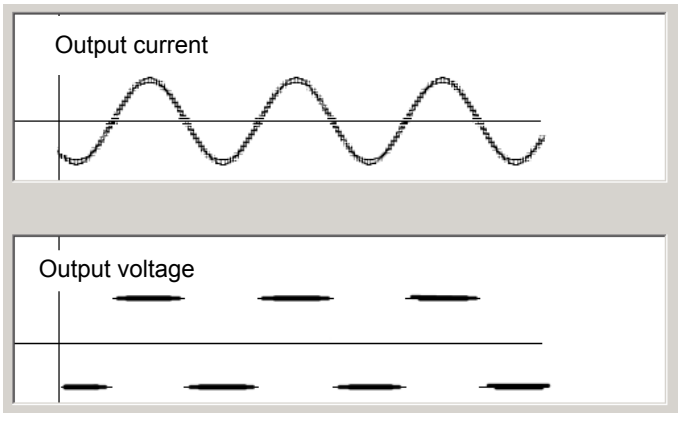
3.1. Main circuit

Power side of inverter contains harmonics and the output side is for PWM (rectangular wave) output. For this reason, it is necessary to use an appropriate measuring device for measuring the current, voltage, and power of each part.

Example: Measuring the output voltage of inverter with tester (moving-coil instrument) and the output current with clamp meter, etc. may cause great measurement errors.







Item	Symbol	Measuring point	Type of measuring device	Remarks
Input voltage	V_I	Line-to-line voltage of input power Between R-S, S-T and T-R (Vr, Vs, Vt)	Moving-iron type AC voltmeter	Measurable with tester
Input current	I_I	Line current of input power R, S, T (Ir, Is, It)	Moving-iron type AC ammeter	Using the clamp meter may cause errors.
Input power	P_I	R, S and T and between R-S, S-T and T-R (w1, w2, w3)	Electrodynamometer type single-phase wattmeter	P_I=w1+w2+w3
Input power factor	$\cos\phi_I$	–	Calculated from input voltage, current and power.	$\cos\phi_I=P_I/(\sqrt{3}*V_I*I_I)*100\%$
Output voltage	V_O	Line-to-line voltage of inverter output Between U-V, V-W and W-U (Vu, Vv, Vw)	Rectifier type AC voltmeter	Cannot be accurately measured with tester, etc. Especially, if measuring with a digital tester which is incompatible with inverter, extremely high voltage may be displayed. (Note 1)
Output current	I_O	Line current of inverter output U,V,W (Iu, Iv, Iw)	Moving-iron type AC ammeter	Using the clamp meter may cause errors. (Note 2)
Output power	P_O	U and W and between U-V and V-W (w4, w5)	Electrodynamometer type single-phase wattmeter	P_o=w4+w5
Output power factor	$\cos\phi_O$	–	Calculated from output voltage, current and power.	$\cos\phi_O=P_O/(\sqrt{3}*V_O*I_O)*100\%$
DC voltage	V_{PN}	DC terminal of inverter Between PA-PC	Moving-coil instrument	Measurable with tester

* If highly precise measurement of input/output voltage, current, and power are required, use the digital power meter.

Note 1: The output voltage of inverter depends on the operation frequency.

Note 2: The output current of inverter depends on the required power.

3.2. Control circuit

Item	Example of terminal symbol (refer to the following table.)	Measuring method	Criterion
Power output terminal	P24, PP, etc.	Measure between each terminal-CC with tester. (DC voltage)	Specified voltage of terminal ±10%
Relay output	FLA, FLB, FLC, etc.	Measure resistance values between FLA-FLC and FLB-FLC.	FLA–FLC: a contact (ON during operation) FLB–FLC: b contact (OFF during operation) During ON: Continuity During OFF: Non-continuity
Open collector output	OUT1, OUT2, etc.	Measure the voltage between OUT1-CC. (with relay operation coil or external power supplied to open collector terminal)	During ON: 1 V or less During OFF: Voltage application
Contact input terminal	F, R, S1, S2, etc.	Sink : Measure the voltage between F-CC.	During ON: 1 V or less During OFF: 24 V (15 V) class
		Source: Measure the voltage between P24-F.	During ON: 1 V or less During OFF: 24 V (15 V) class
Analog input terminal (Voltage input)	VI, RR, etc.	Measure the voltage between each terminal-CC.	0-10Vdc
Analog input terminal (Current input)	II, etc.	Measure the input current of each terminal.	4-20mA
Analog output terminal	FM, AM	Measure the voltage or current between FM-CC. (DC voltage)	0-7.5Vdc-1mA or 0-1mA

Terminal symbol of each model (1)

	VF-AS1	VF-PS1	VF-FS1	VF-S15	VF-S11	VF-nC3
Power output terminal	P24/PLC	P24/PLC	P24,PLC	P24	P24,PLC	P24
Power terminal for external volume	PP	PP	PP	PP	PP	P5
Contact input terminal	F,R,PWR,RES, S1,S2,S3	F,R,PWR,RES, S1,S2,S3	F,R,RES	F,R,RES,S1,S2, S3	F,R,RES,S1,S2, S3	F,R,S1,S2
Contact output terminal (Open collector output)	OUT1,OUT2, NO	OUT1,OUT2, NO		OUT,NO	OUT,NO	OUT,NO
Contact output terminal (Relay output)	FLA-FLB-FLC	FLA-FLB-FLC	FLA-FLB-FLC RY-RC	FLA-FLB-FLC RY-RC	FLA-FLB-FLC RY-RC	FLA-FLB-FLC
Frequency setting voltage input terminal	VI/II	VI/II	VIA	VIA, VIB	VIA	VI
Frequency setting current input terminal	RR,(VI/II)	RR,(VI/II)	VIB,(VIA)	VIC	VIB, (VIA)	(VI)
Output terminal for meter	FM,AM	FM,AM	FM,AM	FM	FM	FM
Pulse output terminal	-	-	-	-	-	-

P24: 24Vdc output terminal (in case of VF-S15, SW1 is set to Sink side or Source side.)

PLC: 24Vdc input terminal

PWR: Power removal terminal (between P24 and PWR)

Terminal symbol of each model (2)

	VF-nC1	VF-A7/VF-P7	VF-A5/VF-A5P	VF-S9	VF-S7	VF-S7e
Power output terminal	P15	P24	P24	P24	P24	-
Power terminal for external volume	P5	PP	PP	PP	PP	PP
Contact input terminal	F,R,S1,S2, S3	F,R,ST,RES, S1,S2,S3,S4	F,R,ST,RES, S1,S2,S3,S4	F,R,RST,S1,S2 ,S3	F,R,RST,S1,S2	F,R,RST
Contact output terminal (Open collector output)	OUT	OUT1,OUT2	RCH,LOW	OUT	OUT1,OUT2	OUT
Contact output terminal (Relay output)	FLA-FLB-FLC	FLA-FLB-FLC	FLA-FLB-FLC	FLA-FLB-FLC RY-RC	FLA-FLB-FLC	FLA-FLB-FLC
Frequency setting voltage input terminal	VI	RR,VI,RX	RR,IV,RX	VIA,VIB	VIA,VIB	VI
Frequency setting current input terminal	VI	II	IV	II	II	II
Output terminal for meter	FM (PWM output)	FM,AM	FM,AM	FM (Output of 4-20 mA on J302-FMC side)	FM	FM (PWM output)
Pulse output terminal	-	FP	FP	-	-	-

P5: 5 Vdc output terminal

P15: 15 Vdc output terminal

P24: 24 Vdc output terminal

RX: 0 to ±10 V input terminal

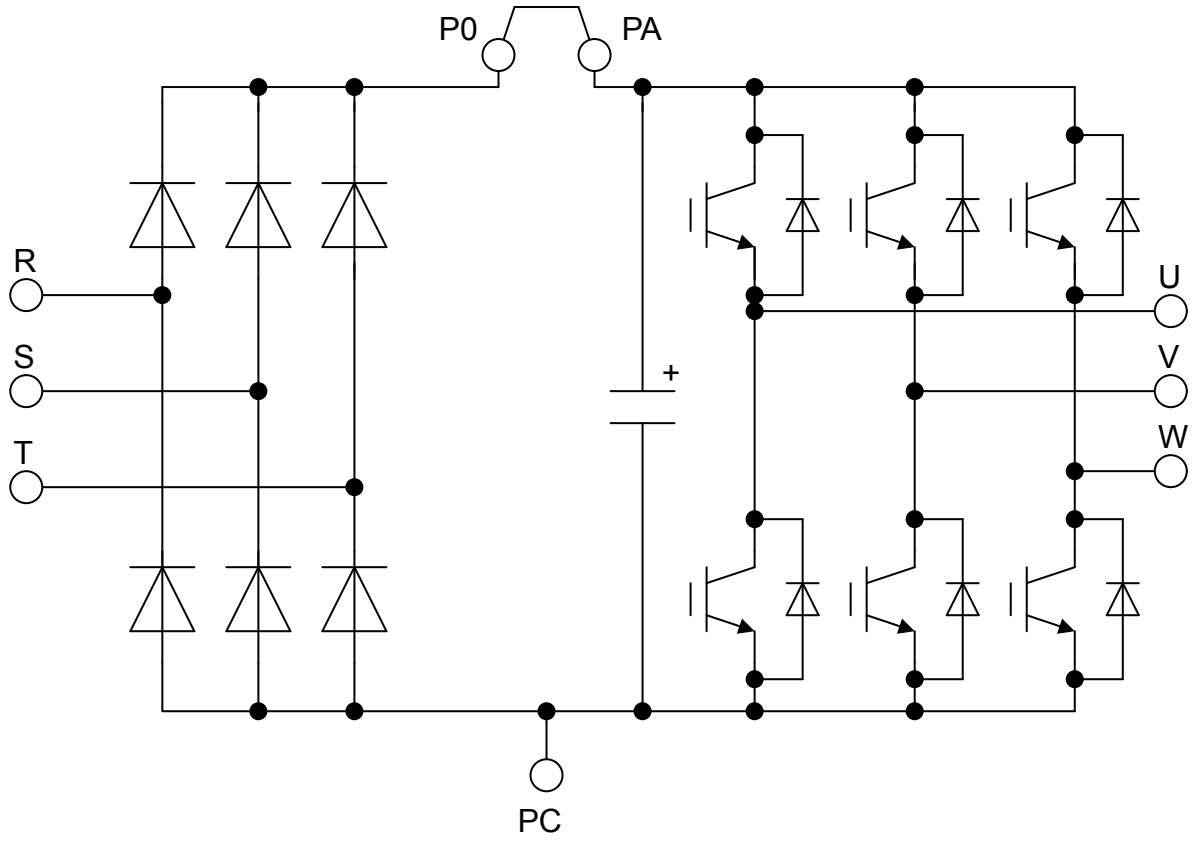
PWM output: Pulse-width modulated output (fixed pulse cycle)

4. Checking method of main circuit under unusual conditions

If any abnormal condition of inverter seems to occur, it is recommended to perform the following check prior to turning it on again:
(Turning on the inverter without check may cause serious damage inside it.)

Note: Make sure that the charge lamp is put off after ten or more minutes.

Required instruments for measurement: Tester capable of measuring resistance values, etc.



* Models without PC terminal: VF-S7 and VF-S7e
* Models without PO terminal: VFA5-3.7 kW or lower models

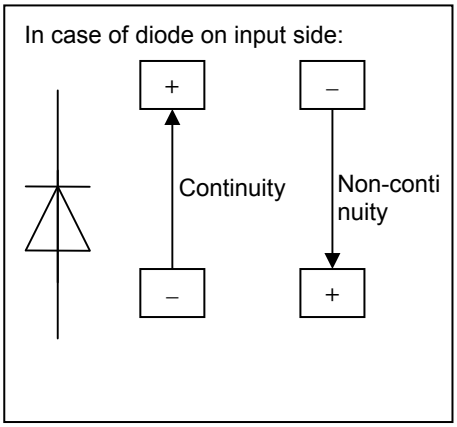
Measuring method and judgment:

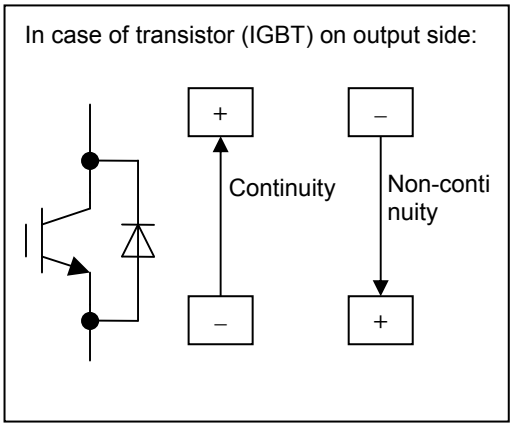
Tester electrode (+)	Tester electrode (-)	Measured value	Remarks
P0(PA)	R, S, T, U, V, W	Continuity	10Ω or less
R, S, T, U, V, W	P0 (PA)	Non-continuity	Infinity
PC	R, S, T, U, V, W	Non-continuity	Infinity
R, S, T, U, V, W	PC	Continuity	10Ω or less
Models without PC terminal Reversed R-S, S-T and T-R terminals Reversed U-V, V-W and W-U terminals		Non-continuity	Infinity * Detectable only when the semiconductor device is damaged in short mode.

In case of bidirectional continuity or non-continuity: Damage of related semiconductor device

* In case of damaged semiconductor device, short mode (bidirectional continuity) is often observed in general.
* Also in case of rush current suppressing resistance (built-in model only) or blown fuse (built-in model only) of main circuit, points of bidirectional non-continuity may be detected.

Note) As thyristor instead of diode on input side is used for the models 200V-18.5kW or more and 400V-22kW or more of VF-AS1 and VF-PS1, measured value between the terminals R, S, T and terminal PA cannot be checked.





[+]: Tester electrode (+)

[–]: Tester electrode (–)